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Previous lectures objective side of scientific discovery.  
Posed exactly between the stools of lay comprehension  
and expert criticism:

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*This afternoon*  
3. Science and Policy

In any case I conclude today with  
a more introspective examination of  
the social and academic roles of the  
scientist

By which I mean the social and ethical role of the scientist. I could have said Science and  
History.

When I consider the roles that scientists play, I can think of

- Discoverer
- Conservator of past knowledge
- Inventor
- Entrepreneur
- Teacher
- Adviser
- Wizard
- Early Warning -- Cassandra

TRANSPARENCY

All of them pose ethical challenges that complicate the scientist's relationship to society.  
Above all, mechanistic science can foretell the consequences of actions. and can empower  
them. Nothing is more immoral than to ignore the constraints of physical reality; but that is a  
burden often resented both by the masses and by the political elites, particularly in the modern  
epoch of unremitting technological change.

In discussing the relationships of science and policy, I will be focussing on process ... not try  
to encapsulate final answers to the most vexing questions in a few minutes. The social  
function of the scientist embraces all the roles I enumerated; it culminates with that of  
Cassandra, whom I identify above all with Albert Einstein. (I recently reread the collection of  
his writings and correspondence: Einstein on Peace; I recall nothing gloomier as I trace his  
history as a pacifist during and post World War I; his reversal as he early perceived the  
threat of Hitler; his writing to President Roosevelt to warn of the possible German  
development of a nuclear bomb; of his post World War II struggles for controlling the bomb  
and for World Order.) 1945, Hiroshima, is the mythical landmark of the loss of innocence.  
Both the power of the Bomb, and its technical intricacy placed special burdens on scientists.  
Nevertheless, it is the essence of democratic responsibility that scientists still act within the  
political process, that they exercise leadership without technical arrogance.

J.D. Bernal has commented that Descartes, faced with Bruno's burning at the stake,  
established the ground rules of the relationship of science to the ecclesiastical establishment,  
that these should be mutually incommensurate and non-interfering spheres. That philosophy

has endured up to the modern era in the relationship of science to statecraft as well. Since 1945, the relationship has been in unresolved crisis: on the one hand, the consequences of science to the social order are too important to be relegated to the sidelines. On the other, the political establishments of all persuasions prefer to "Keep scientists on tap, not on top". Insufferable as this doctrine is, scientists must take care to ask whether they can seek a greater influence on policy without also invoking the converse: a more explicit political control of the conduct of science.

In contemporary society, the scientist is the one who discovers. We should complicate our definition of discovery, usually given as the uncovering of new knowledge; hidden here is a premise that would discount the role of scholarship, the view that all "old knowledge" is visible and understood. Furthermore, what is discovered must be important, it must meet some canonical criteria of significance: implicitly we look for an extension of *understanding* of the natural world. This embraces experimental facts, but, quite as importantly, a certain taste: theoretical insight and the recording, communication, persuasion and dialectic of those insights. All this implies a community of scientists. Without such engagement in that community, without a forum for insistence on and organized, skeptical criticism of claims of conceptual novelty, factual discovery would be useless for still further increments, would be totally sterile. Science is then inherently a social enterprise; an important social function of science is the design and management of its own organization so as to optimize the creative possibilities of its practitioners, and at the same time generate the fruits that justify the ever more costly social investments needed for science to continue. To this day, most political establishments are relatively unsophisticated in their understanding of the essentiality, difficulties, and inevitable long time scales of basic scientific research. They tend to be captivated by nicely encapsulated albeit sometimes very costly projects whose goals appear to be well-defined -- at the expense of maintaining an alert community able to create and capitalize on the most important, which are always the unexpected, discoveries.

It follows that the preeminent social responsibility of the scientist is the integrity of science itself: to engage in discovery to its furthest reaches as a personal goal, to be part of the community of discussion and criticism, to maintain the ethics of truth-telling, to use no other standards than those of scientific accomplishment in the selection and the operation of the managers and gatekeepers of science. To satisfy these responsibilities goes beyond being the most efficient technician in the elicitation of scientific fact, which is the orientation of today's highly specialized disciplinary training. It requires relentless criticism of others' ideas, and equity and compassion in dealing with their claims for personal standing. It may require a

broader study of reaches of science, so as to explore their interconnections, than is achievable in school; and likewise an attentiveness to history, to an understanding of what is known, that may be momentarily a distraction from today's new experiment.

This ideal is not always congruent with the interests of the organization, the corporation or the state. The truth is not always the superordinate goal of public affairs. But if scientists ever compromise themselves on this principle, Nature will be no more forgiving than will be a society which has nowhere else to turn for objective analysis of technically convoluted affairs.

Descartes' compromise was negotiated under force majeure; it was motivated by saving for science its integrity within the sphere in which it could authentically operate. In modern terms, the scientist's ethical role is to avoid prescription. It does take mechanistic science to foretell the consequences of actions. To ignore the constraints of physical reality will injure people however well-meaning the intention. In warning of those limits science may be provocative on matters of religious faith, or its modern extensions in the ideology of the nation or ethnic group.

In the present era, scientists are often called upon, and some volunteer as well, to give advice to society on a multitude of questions requiring scientific expertise. Many of these fall in the category of risk-cost-benefit analyses: the greatest frustration of the scientific expert is in dealing with expectations of perfect safety or zero pollution (in contradiction to an Avogadro's number,  $6 \times 10^{23}$  molecules per gram-mole that assures us that every breath we inhale contains at least one particle of Nefertiti's perfume.) At the next step of that analysis, it may be equally frustrating to be driven to conclusions when the evidential basis remains tantalizingly fragile. However, the scientist has the ability and the responsibility to bring to the analysis the same attention to objective fact, and its delineation from value inclination, as inheres in an experiment: it is impossible to free oneself from bias, but the exercise of scientific judgment within the discipline of the peer group can go far to identify what are the value-oriented, what are the scientific underpinnings, of the tradeoff analysis.

A byproduct of playing a key role in major social decisions is the double-edged scalpel of political power. Many scientists may seek more influence in the political process, partly out of a conviction of what the scientific mind can bring to it, partly for the usual human motives of ambition and quest for power and prestige. I have no doubt that government could be vastly improved by changing the proportion of scientists to lawyers in its legislatures and at the top reaches of the executive. (My text had the note that: So might other organizations,

e.g., corporations and even universities, but I hope no one takes that as a personal comment.) The danger is the inversion of the process: can scientists live at the court of the Prince, can they gain more political power and prestige without the intrusion of political criteria for advancement within the scientific community? Can they achieve their fair share of affluence without being corrupted? Where else can society turn for untarnished advice on matters that may have immense political and economic consequences?

Finally there is the unbidden advice, the foresight about future extrapolations for which early warning may have inestimable social value. It is said that "prediction is difficult, especially about the future." However, scientists are better experienced than most prophets in articulating predictions as hypotheses; the ability to make confirmable predictions is the core of experimental science. That art, together with an understanding of technical complexities of matters pertaining to the environment, to human biology, to weapons effects, to technological capabilities of different groups or countries over time, is indispensable in helping a society foresee the long term consequences of its policies in all those spheres. Many scientific advances in this century -- nuclear fission is the prototype -- have elicited well-founded anxieties about the compatibility of quarreling national sovereignties with the survival of human culture. We are so far from a feasible world model of supranational control of such enormous powers of destruction that scientists today have a special responsibility to assist in the design of the interim arrangements of international accommodation to domesticate such powers. I say scientists, for it is unlikely that other vocations have offered a comparable realism about the destructive power at stake or the possibilities of its containment.

Some say that scientists in a given country should simply refrain from conducting science that could have such fruits. How futile that is! On the one hand, who could have foreseen that studying atomic structure, teasing out the neutrons, could so quickly result in weapons; one would have to suspend all science for that assurance. On the other, that abjuration might offer some self-satisfaction to the individual scientist, but it can hardly alter natural fact. Instead, it merely assures that the technological breakthroughs will be the monopoly of the most unscrupulous. Even with their limited prophetic vision, nevertheless, scientists are uniquely situated to extrapolate the future possibilities of technological advance, to offer all possible early warning to what "society" must do to reap the most benefits, risk the least harm. Today's world, divided North/South as well as East/West, offers many impediments to constructive responses to global threats, be they from natural, social or technological sources. All the more reason for the utmost clarity of foresight.

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Those foresights, together with the inherent supra-national character of scientific advance, have made the scientific profession uniquely motivated and practised in sustained international concern and dialogue. This is already enough to alarm sovereign states, which have sought to humiliate an Oppenheimer, to keep a Sakharov in internal exile. In the past countries that constrained scientific freedom did great injury to their own development, as we know from the examples of Lysenko's persecution of genetics in the USSR, and of the Jewish scientists exiled from Germany and Italy before World War 2. Today, there is an even broader stake. We are observing at the very moment an exhilarating turnaround of East/West perspectives on nuclear arms control: for the first time in decades, we foresee the possibility of reversing the accumulation of the most destructive weapons. The fear generated by these weapons has achieved a life of its own in sustaining security anxieties. We see bold proposals, and new approaches to verification including on-site inspection, in the spirit of Glasnost, that were unimaginable a few years ago. In the long run, self-inspection and self-monitoring must be a centerpiece of verification and compliance. We can never be fully trusting of a nation that denies freedom of expression and communication to its own citizens. Scientists could play a special role as monitors of sovereign compliance with international order. They have the skills, they have the motivation; it remains for them to receive and sustain the freedom to speak out. The shared interests of scientists in the pursuit of a universal truth remain among the rare bonds that can transcend bitter personal, national, ethnic, and sectarian rivalries. To achieve this, still more robust legal guarantees of freedom of access to information and of expression, of assembly and of movement are necessary. These would be bolstered by a corresponding openness of access by scientists to policy councils, keeping in mind the obligations of confidence within lawful limits. The traditions of truth, of international communication, of supranational concern, of personal courage have marked many notable scientists as trusted guardians of shared values. They are often nuisances to the established order, sometimes to the tranquillity of their own fraternity. To bolster the commitment of every government to assure the freedom of expression of its own scientists, to make them credible as tellers of the truth, scientists must redouble their efforts to make themselves worthy of that confidence. This is why examples of fraud in science are so alarming. They cannot be judged merely as minor inefficiencies in the scientific system (from that perspective, the costs of fraud are far outweighed by those of sloppy thinking.) Fraud is a profound betrayal; whom else can the public trust if not a profession avowedly dedicated to the pursuit of truth?

These pathologies aside, there remain several systemic difficulties in the use of expertise in a democratic society. One is the dilemma of confidence at the court: to borrow a phrase from

Wildawsky, when "Speaking Truth to Power".

The most sensitive example is the Office of the President, and his need for expert advice in science in technology. To ensure that all of the relevant options and contingencies are thought about, nothing is more valuable than a candid devil's advocacy, which may be born out of principled dissent with his policies, but should be openminded and restrained to be able to understand his logic as well. I do not suggest that the most hostile opponents necessarily be sought on every issue; there will be ample dissent if any broadly constituted, experienced group of independent thinkers is recruited. Such "loyal critics" are unlikely to be recruited as fulltime officials -- in light of their motives as well as his. He is unlikely to confide in them, however, if they criticize his judgments in public as well as in private counsels. Obviously, they must meticulously respect national security classification of data; but that is not the limit of their responsibility to the executive. Their prestige as members of a PSAC will give them advantages in public debate that a president would be loath to enhance for his openly avowed critics. As part-time, confidential advisers, they do not expect to resign if the president decides contrary to their convictions; but if they speak out inappropriately, they imperil the privilege of the executive's confidence. Academic scientists may be exposed to special pressures on campus, and from the press and the Congress, that could undermine their confidential relationship to the president. For many, especially those who are critical of a given administration's policies, the prospect of being muzzled in public expression of their critical views may place them in a grave dilemma. Nevertheless, I believe that many responsible scientists can be found who will honor the contract, when this is carefully spelled out. A president may then discover that better government is consistent with being reelected, which is well understood to be his cardinal objective.

Another concern is that of perceived elitism out of democratic control: will the expert have unwonted and unaccountable power? This is today's version of Descartes' dilemma, and is answered in part by a separation of the technical from the political judgments: easier said than done. Authentic technical advice will make a strong effort to distinguish them, but that is automatically feasible only in trivial cases. Within the narrow technical sphere, many conclusions remain as judgment calls dealing with matters still in scientific controversy, rather than logical demonstrations -- e.g. just what to say about the severity of nuclear winter or of global warming and rising sea levels. So we look for "authoritative" judgments from "acknowledged experts". The remedy I would advocate is the one we use in scientific dialectic, prompt and open publication of the arguments and conclusions, and spontaneous consensus building involving the entire community. Policy decisions often cannot wait for

such a process, even when it is understood that they are at risk of fault. Sensitive to these realities, our formal advisory bodies, like the National Academy of Sciences or the Congressional Office of Technology Assessment, are criticized for cumbersome due process. It will be hard to avoid that if the imprimatur is to be an authentic one.

A relatively new complication, at least in the biomedical area, is financial conflict of interest. Schools of engineering, business and law have long since worked out a reconciliation of many of the value conflicts, especially as between teaching and industrial service, and these are often mutually synergistic. The sudden expansion of interest in the applications of biology and other basic sciences raises new questions: conflicts may well arise between proprietary applications and research traditionally in the public domain, and substantially funded from public sources. Most of the conflicts are within the domain of university regulation, and regulatory standards are widely accepted.

No one should quarrel with the social merit of providing academic expertise to private industry. Besides its indispensable contribution to technological innovation and efficiency, that independent expertise should also enhance the responsible authenticity of industrial claims for their products, and accelerate early awareness of possible public hazards. Some public grievance may be well founded on the depletion of experts able to speak on controversial matters with absolute and overt detachment, thus complicating if not frustrating considered policy decisions in fields like nuclear energy, pharmaceutical regulation and military procurement. On many important public policy matters we are caught between passionate critics (who have a certain ax to grind in seeking public interest and support) and experts who are already affiliated with the promulgation of a new technology. We have little choice but to call on expertise that is potentially conflicted, demanding open disclosure of conflict as a minimum prerequisite. Final judgments must still be made by those who are beyond imputable taint -- and such are ever harder to find. If that talent is sufficiently highly prized, perhaps society will learn to remunerate experts NOT to engage themselves in industrial consultation, so they can be available for judicial roles.

The legal adversarial system, many scholars will say, is dedicated to "justice" rather than "truth". In court, interested parties in conflict should have equal opportunities to contrive and present their case -- and justice should emerge from fairness of process. The scientist feels quite uncomfortable with formal rules of evidence, excluding data by how they were procured, and at the discretion of a litigant, and especially with having to be presented as a witness for one or the other side. For the same reason, most scientists hesitate to speak out when they

read preposterous allegations about some alleged chemical atrocity: they don't want to be identified as advocates of the company. A few courts are beginning to seek their own advice, independent of the litigants' witnesses, in complex litigation. This is especially important when their rulings will be precedents for many other cases.

At some point, most scientists who delve in policy will become advocates of firmly held positions. In quest of keeping society from disaster, they expose themselves to two dangers: a) that their involvement in political action preempts their continued scientific productivity, and b) that they lend their prestige to a cause more than scientific arguments. Scientists who become publically visible for any reason are hounded to do this, sometimes in very good causes which pose conscientious difficulties of refusal. In the end, both will corrupt the objectivity that is the scientist's unique gift to society.

Finally, we face the question: can the scientist foretell destructive uses of new discovery? Should they be suppressed? Who, if ever, should make such a decision?

I can imagine findings -- e.g. that would make immense destructive potencies available to anyone -- that would give me pause. It is beyond credulity to expect that my own silence would close the matter: what Nature can offer, some person will surely find in due course. (An exception can be made for enterprises that require large scale industrial investment; we think of the atomic bomb as a creature of World War II; and it is just possible that plants for the production of U-235 or Plutonium would not have been built in peace time. It is hard to visualize what could have suppressed the discovery of the neutron, and in turn of nuclear fission. That given, the bomb would have been delayed at most until the next war; and possibly not at all via the path of civil power production.

Most technologies are dual use -- consider space vehicles or the computers that guide them, and their military counterparts. In the medical field, the same knowledge that offers us answers to infectious disease like AIDS offers the potential for more sophisticated biological warfare. In a crude and conflict-ridden world system, voluntary suppression of new science would be a feeble bulwark, likely to leave a monopoly of technological power in the hands of the most unscrupulous. The possibility of ever greater power of mass destruction, and most worrisome its proliferation to less responsible and fanatical groups, has set political culture in a race with technological advance. No one has seen that more clearly than the Scientist as Cassandra; and, yes, time is running out.